Mirroring doubly excited resonances in argon

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INTRODUCTION

The combination of high photon resolution and differential photoelectron spectroscopic techniques has allowed the discovery of new spectral features in the low-energy photoionization spectrum of argon. Previous measurements of the total cross section [1,2] were thought to show all the resonant structures present in the region up to the 3s-ionization threshold. However, we have now observed two new weak and narrow LS- forbidden doubly excited resonances in the $3p^{-1}{}_{1/2,3/2}$ partial cross sections. They exhibit mirroring profiles (with equal and opposite contributions in each channel) which make them undetectable in the total cross section due to essentially total cancellation.

EXPERIMENT

The experiment was performed at the ALS on the Atomic and Molecular undulator beamline 10.0.1. because of its exceptional characteristics (high brightness and a 10 000 resolving power). A photon bandwidth of 3 meV, necessary to carry out the measurements, was used. The photoelectron spectra were recorded with two complementary setups: a hemispherical analyzer fitted with an Integrated Sensor Ltd. (ISL) position sensitive detector and a system of two highly efficient time-of-flight, allowing data collection at several angles simultaneously. (Fig 1 and Fig. 2)

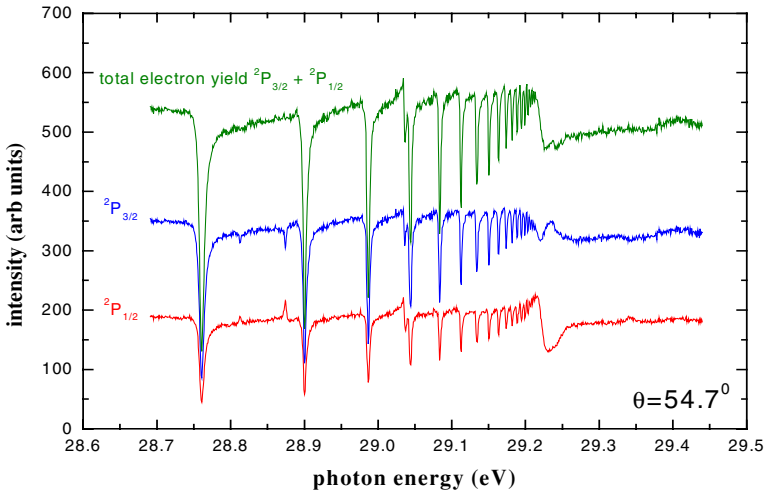

Figure 1. Partial cross sections at 54.7°.

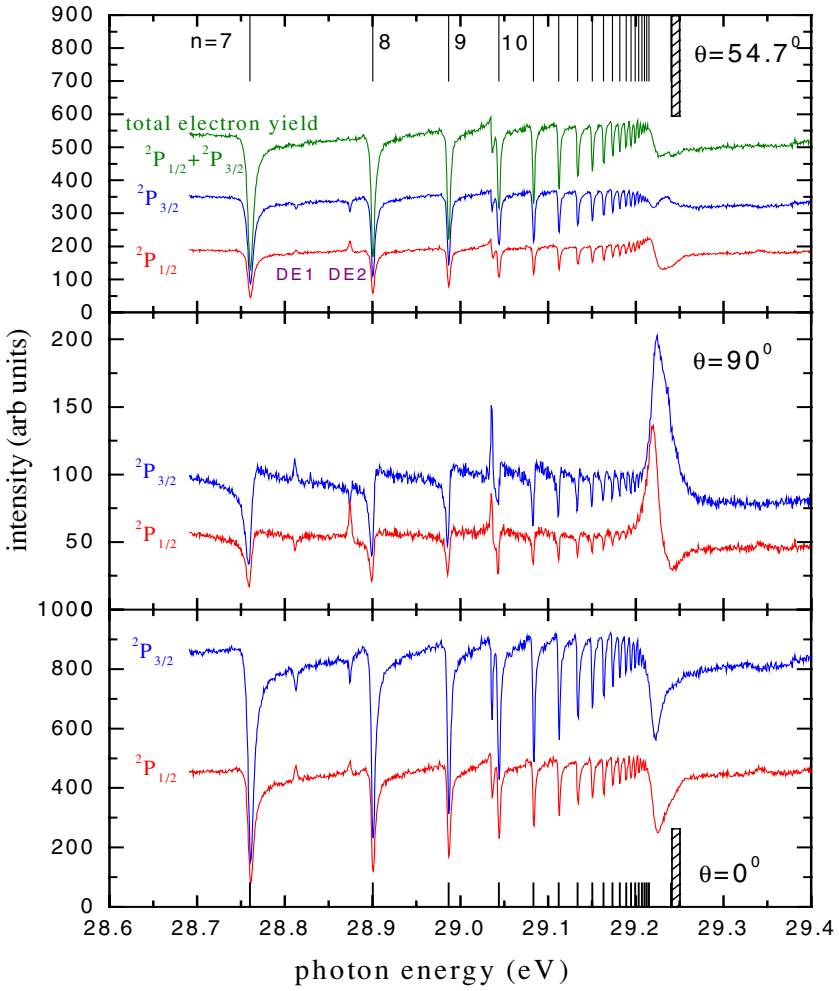

Figure 2.Partial cross sections at 54.7°, 90°, 0°

RESULTS

Considering the energy position of the new resonances, they are attributed to spin orbit induced doubly excited states with triplet symmetry, which are forbidden intermediate states in a pure non relativistic description of the photoexcitation process. Their mirroring character can be qualitatively understood within a theoretical framework recently developed by Liu and Starace [3]. However, a more precise assignment is currently challenging the existing theoretical models that need to go beyond the LS coupling scheme while taking full account of the correlations. Besides its own interest for atomic physics [3,4], the existence of the mirroring behavior will have implications in the design and interpretation of future collisional experiments as some interference effects, evidence of multiple pathways between initial and final states, are simply not detectable with non differential techniques.

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